Five-Year Outlook for Storage Ring Upgrades

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In this note, we briefly discuss possible APS upgrades that may occur in the next five years. We discuss only those options that do not require reduction in scheduled operation.

Global Long Straight Sections: Lengthening all or most of the straight sections (SS) is a practical possibility. The most straightforward option increases the SS length by 2.9 m, with reduced optics flexibility. This is similar to the first stage of ESRF's plan [1]. A more involved and challenging option is to shorten the dipole magnets and quadrupole magnets [2, 3]. In this case, the SS length increases by 3.57 m, while we retain the nominal flexibility of quadrupole triplets on each side of the SS. The effective emittance will be in the range of 3.5 to 4.0 nm for both options.

Sector-by-sector customization. Many sector-by-sector customizations are nominally possible. These include long SS (up to 6 m longer)[4]; reduced horizontal beamsize, e.g., 120 μm [5] or perhaps as low as 40 μm [6] ; higher-energy dipole radiation [7]; and split dipoles to accommodate extra IDs [8]. The risk of is increased emittance, poor lifetime, and poor injection efficiency. Careful planning and study of the combined options is needed to ensure that performance of the APS is not compromised.

Canted devices. Canting insertion devices [9] in more sectors will have essentially no impact on operations. Increased (>1 mrad) canting angle is possible but requires upgraded corrector magnets [10].

Improved coupling control and/or smaller vertical emittance. Some beamlines are sensitive to the vertical emittance and x-y tilt. Improved control of this requires additional skew quadrupoles and/or a method for compensating for decreased lifetime. One option is to install skew quadrupoles in long straights as part of a long SS upgrade. Another is to convert/augment some existing steering magnets with skew quadrupole fields, either globally or in a coupling bump[11].

Higher current. The storage ring is capable of storing significantly higher current than the 100 mA presently used for operations. Operation at 200 mA in 324-bunch mode or 160 mA in 24-bunch mode is feasible [12] within a five-year time frame, provided beamlines and front-ends are upgraded. Operation in hybrid mode at 200 mA with 16 mA in the singlet should also be possible. Faster top-up will almost certainly be needed, although lifetime improvements may mitigate this concern.

New bunch patterns. New bunch patterns have been explored in the past and could be envisioned with the next five years. For example, changing from 24-bunch to 18- or 12-bunch operation might be advantageous, but is not possible now due (mostly) to rf cavity damper issues. A modified hybrid mode is also under development that would provide three "super-bunches" instead of the 56-bunch train [13].

Improved bunch purity. Although not trivial in combination with top-up, a storage ring bunch cleaning system could be developed that would remove beam from nearby buckets (i.e., ± 1 through ± 3 buckets). Possible techniques are gated rf knock-out [14] or use of a bunch-by-bunch feedback system.

Short x-ray pulses. Use of Zholents' crab cavity scheme[15] for producing short pulses has been extensively studied. It should be possible to provide under 2 ps FWHM pulses of 10 keV (or higher) x-rays with 1% of nominal intensity to a few beamlines [16]. Impact on other users is expected to be minimal.

Lifetime improvement. Since APS uses top-up mode most of the time, we are relatively insensitive to lifetime. However, longer lifetime means less-frequent top-up and reduced radiation damage. We could also offset lifetime decreases due to other desired changes, e.g., higher current operation, new bunch patterns, or modified lattices. Lifetime improvement probably requires lower chromaticity, which should be possible with a transverse bunch-by-bunch feedback system; a prototype is now under development.

Quieter top-up. Some of the modification discussed above may lead to shorter lifetime, which can be mitigated using faster top-up. Ideally, top-up should be made transparent to users. One approach is to move all the injection hardware to a single long straight section. A new approach[17] is to use pulsed sextupole magnets, although this seems to be challenging given the large emittance from the APS booster. Upgrading the realtime orbit feedback system will also help suppress top-up related orbit transients.

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